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X.—*Note on the Sponges Grayella, Osculina, and Cliona.*
By H. J. CARTER, F.R.S. &c.

AT the suggestion of my kind friend Dr. J. E. Gray I have examined Schmidt's *Osculina polystomella* and some living species of *Cliona*, for the purpose of ascertaining how far these sponges were allied to *Grayella cyathophora* (which I described and figured in the 'Annals,' ser. 4. vol. iv. p. 189, Sept. 1869), with the following results.

And first as regards *Osculina polystomella* (Schmidt's 'Sponges from Algiers,' 1868, second Suppl. to 'Sponges of the Adriatic Sea,' 1862, pl. 1. figs. 1-13), it must be premised that this sponge was examined by the able author after preservation in spirit, and that Lacaze-Duthiers, who contributed the specimen, furnished also figs. 1-8 of the illustrations.

At first sight of the plate, one is inclined to say that this sponge is closely allied to *Grayella*, except that fig. 1, which is stated to represent its natural size, far exceeds *Grayella cyathophora* in the dimensions of its papillary elevations. Lacaze-Duthiers's fig. 2 would represent the mammilliform vent, and figs. 3-7 the papilliform sieve-like orifices of the inhalant area, together with (fig. 8) their sarcodal columns and projecting spicules, in both *Grayella* and *Osculina*. But when we come to Schmidt's description, then also comes a discrepancy, viz. that *all* these papilliform figures are stated to be excurrent orifices; and the only example of an incurrent or inhalant set is that in Schmidt's fig. 11, where a few little apertures are situated on one side of the disk of a papilla marginated, but apparently unfringed, from contraction at or after death.

It seems very probable to me, after the examination of *Cliona northumbrica*, Hancock, which I have just made (for *Ann. & Mag. N. Hist.* Ser. 4. Vol. v. 6

this is the *living* species that I have had under observation), that Lacaze-Duthiers's figures (viz. 1-8, which are the principal illustrations to Schmidt's description) were made during life, and that Schmidt's own (viz. 9-13 inclusive) have the contracted forms presented to Schmidt in the preserved specimens.

Although Schmidt's section of the two papillæ (fig. 12), representing the sarcodal columns in connexion respectively with large canals below them, while the latter, again, are stated to open on the surface by several little orifices between the columns (that is to say, sieve-like), is exactly like the structure of the papilliform inhalant area of *Grayella* (see my figures, *l. c.*), yet in fig. 11 Schmidt represents an osculum, or large excretory orifice, in the centre of the margined disk of a papilla, in addition to the sieve-like group of little pores close to the margin. If Schmidt be right in considering this an osculum and the group of smaller apertures "inhalant pores," then we must infer that the osculum is in connexion with its own excretory canal, and that the pores have their own inhalant canals or canal beside it, in which case this is an instance of the combination in one papilla of both organs, viz. the excurrent and incurrent system of canals respectively—a possible combination which I do not deny, but of which I have seen no example either in *Grayella* or *Cliona*.

I say "if right," because Schmidt's observations having been made on a preserved specimen, his distinction of excurrent and incurrent apertures must be made from resemblances, as, I think, is stated in his description.

Now, if Lacaze-Duthiers's fig. 8, representing a mammilliform eminence terminated by a single large orifice, be viewed as an excurrent organ, and the fringed papillæ respectively with their sieve-like orifices as inhalant area, then the analogy between *Grayella* and *Osculina* becomes very strong. But in Schmidt's description, as I have stated, they are all alike regarded as excretory; there is no part illustrative of the great inhalant system but the little insignificant group of orifices placed on one side of the disk of a papilla otherwise devoted to the excretory system, as above mentioned.

My impression of such orifices is that, for the most part, excretory openings are large, single, and simple, and that it is the oral ones which are tentaculated, fringed, or otherwise ornamented with useful appendages. In *Actinia* and *Hydra*, where there is but one orifice for both purposes, it is ornamented; but certainly in the Polyzoa and Ascidiae, where there are two, it is the oral, and not the anal, orifice which is thus complicated. Hence, from analogy, I should be inclined

to think that the fimbriated papillæ of *Osculina* were the inhalant, and the less ornamented conical ones, with large single apertures respectively, the excretory organs. So, "at first sight of the plate," as above stated, *Grayella* and *Osculina* appeared to me to be very closely allied.

Let us now see how far the study of *Cliona* in a living state assists us through these difficulties.

On the 6th December, 1869, after a storm, I picked up on the beach at this place (Budleigh-Salterton, Devon) a specimen of *Laminaria*, in the inner and vaulted portion of whose conical bunch of roots was fixed a small oyster-shell permeated by a species of *Cliona*, which subsequent examination proved to be that so faithfully described and figured by Mr. Albany Hancock as *Cliona northumbrica*, in the 'Annals,' ser. 3. vol. xix. p. 237, pl. 7. fig. 1, April 1867.

The shell in which the specimen was situated, having been released from the roots of the seaweed, was immediately placed in sea-water (renewed daily) and examined for eight days successively. It was about two inches in diameter, and originally fixed obliquely upwards among the roots of the *Laminaria*, some small ones of which were attached to its outer or convex side, while the inner or concave part of the shell was free from all root-attachment and faced the hollow part of the coniform root-bunch. No doubt the *Laminaria* had been attached by its other roots to a rock but trusting too much to the surface of the otherwise unfixed oyster-shell led to its being torn from its site by the waves, and thus thrown upon the shore where I found it.

There were twelve papillæ of different sizes scattered over the convex part of the shell, among the attachments of the roots of the *Laminaria* (which were all cut off short for better observation), and the same number on the concave surface or that directed towards the hollow cone of the root-bunch. Six of the latter were papilliform vents presenting respectively a more or less elongated conical form, truncated at the extremity and provided with a single large circular aperture, circumscribed, when fully extended, by a delicate thin margin. The rest of the papillæ on both sides were more or less expanded, or obversely conical, presenting a fimbriated surface radiating more or less from the centre, in which were irregularly scattered a few small circular orifices varying and less than 1-600th of an inch in diameter.

The fimbriated surface consisted of feather-like extensions based on groups or bundles of pin-like spicules pointed outwardly, which, issuing with the soft sponge-substance of the papilla, were thrown apart as the sarcode raised itself upwards

out of the circular hole in the oyster-shell, and thus, opening flower-like to the water, disclosed at the same time those beautiful feather-like appendages of the circumference, together with the minute pores of the centre, for inhalation.

The form of the vents, too, if anything, when fully expanded, tended to a trumpet-shaped opening; but the margin of all the orifices, both inhalant and excurrent, was minutely serrated by the projection of the pointed ends of spicules tied or webbed together by transparent sarcodæ, in which the denser parts, hanging about the thrown-aside spicules of the bundle, produced the feather-like forms mentioned. Thus the apparent fringe was not in separate portions, as figured of *Osculina*, but in the midst of the transparent sarcodæ.

The largest of the papilliform inhalant aræ did not exceed the 1-12th of an inch in diameter; and they were all more or less different in shape, varying from a circle to an elongated ellipse. When fully expanded, the diameter of the head or inhalant area was always greater than that of the cylindrical body as it issued from the circular hole of the oyster-shell, and, although funnel-shaped at the commencement, became nearly flat when fully expanded. The body, too, was often inclined or bent to one side, so as to give a drooping position to the head, which, in the elongated elliptical forms, closed by approximation of the sides, and in the round ones by contraction towards the centre.

Although, when somewhat contracted and funnel-shaped, the inhalant area presented the appearance of an osculum, on no occasion were the two seen in the same papilla, as in Schmidt's illustration, nor was there seen any transformation of the inhalant into the excretory papilla, nor *vice versâ*, as might be anticipated from a knowledge of the internal structure connected with these systems in sponges generally. The oscula and inhalant aræ respectively and invariably continued the same.

When first examined, the papillæ had all withdrawn themselves within the margin of the holes in the oyster-shell, but, after rest, began gradually to issue, first in a conical form, when they appeared to be covered with minute black holes, which were the then bare ends of the pin-like spicules bristling in a radiating direction all over the surface of the cone. As, however, the sarcodæ ascended the spicules (and, so to speak, hung itself out upon them, probably for the purpose of aëration) the whole top fell asunder into the fimbriated form mentioned; while the reverse quickly took place if, under this state, the papillæ were touched with the point of a needle, proving the sensibility of sponges to a mechanical stimulus.

No two papillæ, as before stated, presented exactly the same form; but the general plan in all was that described.

When exposed to the direct rays of the sun, the inhalant aræ all contracted, while the six vents, on the contrary, appeared to be, if anything, more expanded by the same stimulus,—showing, also, that sponges are sensible to light. The inhalant aræ also contracted on motion, while the vents remained unaltered; so that, to observe the former in an expanded state, it was necessary to subject them to as little motion as possible while bringing them under microscopical examination. In short, the vents were seen to continue their office while that of the inhalant aræ appeared to be suspended.

I could see, with the microscope, particles issue from the vents, but could never do so, one way or the other, from the apertures of the inhalant aræ; nor could I see any signs of an inhalant current in the latter by the addition of finely levigated solutions of both carmine and Indian ink, applied separately, such as, under similar circumstances, may always be seen in *Spongilla*.

Then it should be remembered that the incarcerated *Cliona* is probably nourished by the remains of animal matter in the substance of the oyster-shell in which it burrows, while *Spongilla* and the free sponges must obtain it from the surrounding element: hence the inhalant area in the former may be much less active than in the latter; and hence particles of refuse matter may be seen to issue from the vents in *Cliona* while the inhalant aræ are closed.

The largest holes of the vent-papillæ (which only contained one each) were 30-800ths of an inch in diameter, and the largest apertures in the inhalant aræ about the 600th of an inch in diameter; in short, the former were not much less than thirty times as large as the latter.

Spicules.—The smooth, nearly straight, pin-like spicules of *Cliona northumbrica*, which are by far the largest, viz. 73-6000ths or 1-82nd of an inch long in the interior, chiefly occupy the papilla, where, although a little less in size, they exist exclusively of all others and are so numerous as to form the greater part of its bulk; the largest spinous curved fusiform spicules, pointed at each end, which chiefly occupy the sarcode of the interior, are about 25-6000ths inch long; and the minute sinuous ones which accompany them 3-6000ths of an inch. Thus we have the spicule-formula of *C. northumbrica* given by Mr. Hancock (*l. c.*), saving the unimportant trifling discrepancy in measurement.

Lastly, similar sponge-substance to that of the interior, which was present in retiform patches on the exterior of the

shell, was found to be charged exclusively with spicules exactly like the large ones of *Grayella*, viz. smooth, straight, more or less cylindrical, round at one end and pointed at the other, 38-6000ths inch long,—a trifle, certainly, less in size, but this does not lessen the significance of the fact.

To the retiform patches of the exterior, charged with the spicules just mentioned, may be added others of a similar kind without spicules, but composed of spherical vesicles and innumerable small monociliated sponge-cells, not unlike the "ampullaceous sac" and its ciliated sponge-cells described in my account of the "Ultimate Structure of *Spongilla*" (Annals, ser. 2. vol. xx. p. 22, pl. 1: 1857).

To what, then, do these observations lead respecting the point in question? Viz. to the conclusion that *Grayella cyathophora*, *Osculina polystomella*, and *Cliona northumbrica*, if not the Cloniadæ generally, all belong to the same family.

In *Cliona northumbrica* we have the fimbriated inhalant area and the single-holed papillary vent almost exactly like those figured of *Osculina polystomella* (l. c.), if we are to regard the latter as inhalant and excurrent openings respectively; and as this inference is based upon observation of an allied species in the *living* state, it seems to me more likely to be correct than Schmidt's interpretation, from resemblances, of the offices of these parts on a dead one, however well preserved in spirit; that is, that Schmidt has, by his own mistake or that of others, assigned the wrong function to the fimbriated papillæ. Surely that little group of pores placed subordinately by the side of an osculum in the same papilla cannot alone be illustrative of the great inhalant system of the beautiful *Osculina*!

Again, the pin-like spicules of *Osculina* can hardly be said to differ from those of the Cloniadæ; while in the fimbriated papillæ these are arranged in a radiated direction with their points projecting beyond the sarcodæ, just as the spicules are in the papilla of both *Cliona northumbrica* and *Grayella cyathophora*. Indeed there are many pin-like spicules of the former exactly like those of *Osculina*; and the clavate one, also given by Schmidt in fig. 13, is merely a variety of the nearly straight pin-like spicule when found among the latter.

Then, as regards *Grayella*, it is remarkable that the patches of *Cliona northumbrica* on the outside of the oyster-shell and those of the interior should almost exclusively be charged respectively with the same kind of smooth straight, and curved spinous spicules which characterize *Grayella* (Annals, l. c.), while the pin-like or larger ones, exclusively of *all* others, occupy the papillæ of *Cliona* and project beyond the sarcodæ, as the spicules in both *Grayella* and *Osculina*.

Thus the presence of the same kind of papilliform inhalant and excurrent organs, and the same kind of spicules, arranged in the same manner in these three sponges, seems to me indubitably to claim for them all the same family.

It might with justice be stated that the specimen of *Grayella* which I described was also preserved in spirit, and that I also decided "upon resemblances" the offices of the oscular and inhalant papillæ respectively; and, further, it is possible that, in the living state, these papillæ might have presented different forms; perhaps the latter might have presented a finbriated margin. But, be this as it may, he must be obtuse indeed who could not see in my illustration of *Grayella cyathophora* (which is as true to nature as I could make it) what I saw in the actual specimen, viz. which is which; and it is this which I fancy that I can see in Lacaze-Duthiers's illustrations of *Osculina polystomella*, chiefly through my observations on the living *Cliona*, although I acknowledge that the differences of the two systems in *O. polystomella* are not so unmistakably marked as they are in *Grayella cyathophora*.

Grayella cyathophora and *Osculina polystomella* appear to me to be free forms of the Cloniadae, such as the so-called genus *Raphyrus*, which is but a free form of *Cliona celata*.

The piece of oyster-shell on which I have made my observations is too free from foreign organisms, both animal and vegetable, for me to suspect that I have been confounding more than one kind of sponge with another, as has been imputed to Mr. Hancock by Dr. Bowerbank (Ray Soc. Pub. 1866, 'Monograph of Brit. Sponges,' vol. ii. p. 216). Undoubtedly it is *Cliona northumbrica*, so truthfully described and illustrated by Mr. Hancock in the 'Annals' (*l. c.*), and under "*Pione*" in Dr. J. E. Gray's proposed arrangement of the Spongiadae (Proc. Zool. Soc. Lond. May 9, 1867, p. 525). Undoubtedly, too, if the almost liquid Myxogastres can work their way through hard wood to the surface, if the like delicate endophytes *Chytridium*, *Pythium*, &c. can pierce the horn-like coverings of Algae, and the soft cell of *Zygnema* can dissolve its prison-walls for exit and conjugation, the amceboid sponge can burrow among the layers of an oyster-shell for its subsistence—views so ably put forth by Mr. Hancock (*l. c.*) that I am only astonished how Dr. Bowerbank (*op. cit.* p. 221) could treat such "patient merit" so unworthily.

Almost all that I have stated was written in other and better words by one of my earliest and kindest friends and teachers, Dr. Grant, in 1827 (Edin. New Phil. Journ. vols. i. & ii.), who, at that comparatively early period in the investigation of the nature of the Spongiadae, assigned the papilli-

ferous *Cliona* to the Zoophytes, from the form of its papillæ, probably, rather than from their function.

Others have since verified his observations, although not altogether according with his conclusions; and my introducing the former again here from personal examination, must plead for excuse only in the special object of comparison for which this examination has been instituted.

I have stated that the pin-like spicules are chiefly confined to the papillæ, where, under certain conditions, they project beyond the sarcode, and under others are more or less covered by it. They come under the designation of Dr. Bowerbank's "defensive spicules," but seem no more to merit that appellation than thorns on rose-bushes. If I might presume to assign any special function to them, without infringing upon the illimitable uses for which every object in nature is provided, it would be that their chief service is to support the delicate sarcode when spread out like branchial appendages, for the purpose of aëration. Of the uses of the other spicules with which the sarcode of *Cliona northumbrica* is charged, both externally and internally, I shrink from even hazarding an opinion.

Lastly, I have above used the expression "so-called genus *Raphyrus*," of whose single species, viz. *Raphyrus Griffithsii*, this beach has afforded me several large and living specimens (one of which I have at this moment in sea-water under examination); and I feel bound to state that whenever I have compared it with a fine specimen of *Cliona celata* found at Exmouth by my friend Mr. Parfitt, who kindly presented it to me, the result has been a corroboration of Dr. Johnston's view, who regarded it as a free form of *Cliona celata*, and a complete subversion of the slender grounds on which Dr. Bowerbank has made it a separate genus (*op. cit.* vol. ii. pp. 215, 216). The specimen of *Cliona celata* which I have mentioned presents the same kind of raised areola, more or less plugged with sponge-substance, over the hole of the oyster-shell from which it protrudes, the same kind of cellular structure interiorly, and the same form and size of pin-like spicule, with its slight capitate variations, as the so-called *Raphyrus Griffithsii*, which to me is but a coarse form of a sponge which, not having the cavities of a shell to support it, has to provide itself with a stronger architecture.

I am not the first person, too, who has noticed *Cliona northumbrica* in this neighbourhood; for it is mentioned by my intelligent friend Mr. Parfitt in his paper on the "Marine and Freshwater Sponges of Devonshire," printed in the Trans. Dev. Assoc. for Advancement of Sc. & Lit. 1868,

where, under Dr. Gray's name of "*Pione*," he states that *Cliona northumbrica* is not uncommonly dredged off the south coast of Devon, "in *Buccinum undatum* and in the old valves of *Cardium edule*," testifying at the same time to the "excellent" description of this species, in the 'Annals,' by Mr. Albany Hancock.

In my specimen, which is not much the worse for ten days' confinement, there are no raised areolæ of sponge-substance (spicules and sarcode) bordering the holes in the oyster-shell, as in the specimens of *Cliona celata* and *Raphyrus Griffithsii* to which I have alluded; and I think it not improbable that, although the papillæ would be much contracted by death, still some of them would remain much beyond the holes in the oyster-shell, which, if dissolved off, would give them a similarly elevated position above the other sponge-substance to that presented by the papillæ in *Grayella* and *Osculina*.

Postscript.

Since the above was written, three or four of the inhalant papillæ, now in a semicontracted condition, on the concave side of the oyster-shell, have presented a single funnel-shaped hole in the centre respectively, which, being so much larger than the original apertures, led me to think that they must be vents; but on placing them under the microscope, particles were observed to be whirled into them, apparently in a spiral manner, showing at once that they were not vents, and affording positive evidence, which had not been before obtained, of the inhalant function of these papillæ.

The vents are still active, and the inhalant papillæ as sensitive to light as when first the *Cliona* was placed in confinement (now thirteen days ago), which would hardly have been the case had the *Cliona* not been drawing its nourishment from the organic matter in the oyster-shell. On the other hand, a living piece of *Raphyrus Griffithsii* (which I regard as a free form of *Cliona celata*), and which was placed in sea-water renewed as often as that of the *Cliona*, ceased, after three days, to show any active signs of life whatever.

The papillæ which presented respectively the single funnel-shaped hole in the centre were, with the exception of the rim, very like Schmidt's figs. 10 & 11 of *Osculina polystomella* (l. c.).

Finally, it should be noticed that the papillæ in *Cliona northumbrica* ceased to present their fimbriated forms about the sixth day after confinement, and, showing signs of decline

generally about the 18th, it was transferred to spirit and water for preservation.

Dec. 31, 1869.—On this day I picked up on the beach, after a heavy gale from the south, among other living specimens of sponges, two compact portions, rounded off by friction among the shingle, each about $1\frac{1}{2}$ inch long, not quite so broad, and rather compressed, of a light yellow colour tinged with red, and presenting a single large hole at one part. They were portions of *Halichondria suberea*, Johnston (Brit. Spong. p. 139, pl. 12. figs. 4-6); and on making a longitudinal section of them respectively, each displayed the interior cavity of a univalve shell, about an inch long, with the spire and columella complete; only the whole was composed of sponge-substance, just as much as if it had been analogously lapidified by fossilization. Indeed, to use a mineralogical term, the sponge internally was a pseudomorph of the shell it had replaced. How the cavity of the shell had been maintained during the transition can only be accounted for by the presence of a hermit-crab (*Pagurus*), which, although still in one of the specimens, had quitted the other; so that the *Pagurus* must have been in the cavity of the shell all the time that it was being replaced, particle after particle, by the sponge—a process, however, which might have gone on very rapidly, as inferred by Montagu (*op.* Johnston, p. 140, *l. c.*).

This was not all; for each sponge had enclosed at the summit of the columella a little *Murex* (*corallinus*?), about four lines long, fresh in appearance, but empty, on which were deposited, both inside and out, but chiefly between the costæ, lines of spherical gemmules, of a yellow colour, and varying from 4- to 8-830ths of an inch in diameter, which gemmules were themselves already sunk to almost half their diameter into the substance of the *Murex*.

The gemmule was composed (when nearly dry, in which state the specimens were examined) of a minutely dimpled, amber-looking, soft, coriaceous envelope, lined by one more delicate, colourless, and transparent, containing a number of spherical cells about 1-1660th of an inch in diameter—in short, just like the gemmule or so-called seed-like body of *Spongilla*, whose grouping (here exclusively round the little *Murex*) they otherwise generally resembled.

This at once decides the question of the possibility of certain sponges feeding on the organic matter of shell-substance, just as certain Fungi feed on woody tissue. And in this instance, we must regard this sponge (*Halichondria suberea*), from its habit, true pin-like spicule (that is, with a turban-like head), compact structure, minute cancelli, and small, although

defined, canalicular system, as one of Dr. J. E. Gray's family of Clioniadae.

The yellow colour and dimpled appearance, respectively, presented by the coriaceous envelope of the gemmule is owing to its being composed of minute spherical cellules, about 1-3700th of an inch in diameter, situated about the same distance from each other, but united together, in a stellate form, by intervening straight tubules, five or six in number, radiating from each cellule, similar to what is seen in the microscopic cell-structure of fossil Foraminifera, ex. gr. *Orbitoides*; and it is in the intervals between the cellules and radii that the dimples occur.

XI.—*Reply to Mr. Frederick Smith on the Relations between Wasps and Rhipiphori.* By ANDREW MURRAY, F.L.S.

I was much pleased to read my friend Mr. Frederick Smith's commentary on my paper about Wasps and *Rhipiphori* in the last Number of the 'Annals,' although I see that I have not succeeded in converting him to my views. There is nothing like the collision of opposing minds for eliciting truth; and it is always pleasant to find another taking interest in a subject which has excited our own, especially when it is so fairly and honestly handled as every subject is on which Mr. Smith expresses his opinion.

With the help of that fairness, I do not yet despair of bringing him round; and for that purpose, as well as for the sake of those who may have been convinced by his arguments or led away by the authority of his opinion on a subject on which he is *facile princeps*, I shall ask him and them again to weigh the difficulties which his view of the question presents. In my last paper I was more concerned in stating my own observations than in controverting the opinions of others; but I shall now pass in review the whole facts that we know on the subject, either from Mr. Smith, Mr. Stone, myself, or others, and endeavour to see with which explanation they best agree.

Mr. Smith agrees with me that the *Rhipiphorus* lays its eggs in the cells of the wasps, and that in the instances in which I saw two eggs in one cell, one of them must have been a *Rhipiphorus*; that gives us the form of its egg and its position and mode of attachment in the cell (which are all identical with those of the wasp's). When the wasp's egg is examined in its early stage, it is seen to be simply an oval egg, with a smooth semitranslucent shell, through which, at a later